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LOGGING RESIDUE AND SLASH COLLECTION IN THE CENTRAL SIERRA

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Conventional forest management practices produce large volumes of logging residues which remain in the woods. This annually results in the creation of between 4.5 and 6.5 million dry tons of slash on California's timberlands (California Department of Forestry, 1978). Some of this residue is disposed of through fire hazard reduction practices, but the majority remains intact on the logging site. In an effort to better utilize this large amount of residue and reflecting an increased interest in the use of wood as a fuel source, the California Department of Forestry conducted a research project to obtain information on the cost of gathering forest slash and residue and converting it into heat energy for steam and electricity generation.

The project involved yarding to a landing all logging residue and slash greater than four inches in diameter at the large end and four feet in length. At the landing the material was chipped, loaded into vans and tranported to a local sawmill where it was utilized as hog fuel in its steam generation facility.

SUMMARY OF FINDINGS

- Timber harvest residues can be collected and transported 35 miles to a central site and utilized as energy chips at a cost of $39 per dry ton ($3.08 per million Btu).2/

- This residue harvesting project conducted on 42 acres in the central Sierra Nevada mountains collected a total of 873 dry tons of energy chips (20.8 dry tons per acre). The moisture content of the chips averaged 29.6% (wet basis).

- The net useful energy produced by the project totaled 11,100 million Btu while 484 million Btu were directly consumed--a positive process energy balance of 23:1.

- Dependent on transportation distances, forest residues can be cost competitive with residual fuels oils as a heat energy source.

- There is a need for the further modification of existing harvesting equipment and practices to provide for the special requirements of forest residue collection.

- The general findings of this study can be projected to similar central Sierra locations. However, because of the nature of the forest residue resource, the exact data and cost information generated by this project are site specific to the Blodgett location.

The site of the study was a 63 acre parcel of timberland on the University of California's Blodgett Forest Research Station (Figure 1). Located 30 miles east of Auburn at the 4,000 foot elevation, the site has a diverse species composition, mostly white fir, sugar pine and Douglas-fir with smaller amounts of incense-cedar and ponderosa pine. The site is being managed under an unevenaged system and has been harvested three times in the last 16 years, most recently a regulatory cut in the summer of 1977 (Heald, 1978).

While the slight slopes (less than 10%) on the project site created few yarding problems, stream protection exclusions and weather related constraints reduced the project area from 63 acres to 42 acres.

In preparation for the harvesting of the residue and for safety reasons, all small snags and trees gravely damaged by earlier harvesting activity were felled.

2/ All costs and dollar amounts are in 1978 dollars.

The site was then inventoried to estimate the total amount of logging residue and debris. Inventory data was obtained using a modification of Brown's method, a planar intersect sampling technique, to determine the tons of slash and residue per acre (Brown, 1974).

Upon completion of the inventory, collection activities were initiated utilizing two John Deere 540A rubber-tired skidders equipped with grapples, one supplemented with a hydraulic boom. To increase the efficiency of the yarding process and reduce the intrusion of heavy machinery onto undisturbed areas, some of the smaller slash was concentrated by handpiling while larger pieces were either prebunched using the skidder or yarded individually to the landing. While an attempt was made to utilize only existing skid trails, the widely distributed residues required some additional intrusion and disturbance which resulted in increased injury to existing regeneration, all of which was minor.

The minimum dimension requirements of four feet in length and four inches in diameter were selected for two reasons. First, since most nutrients are incorporated in the smaller slash, they are retained on-site by harvesting only the residue larger than four inches in diameter. As a supplementary project, a U.S. Forest Service-CDF cooperative study is currently being conducted by Dr. Paul Zinke of the University of California, which will ascertain a diameter limit where the harvest of forest residues should be stopped to prevent excessive nutrient drain on a site. The smaller diameter slash also provides an important mitigating influence on erosion processes.

After skidding to the landing, the slash and residue material was decked for processing by a Morbark Model 22 "Chiparvestor". Equipped with a hydraulic boom for self-feeding, the machine chipped the wood and loaded it into a van. Material which was too large for the chipper's 22 inch diameter capacity was decked on the landing for later transport. Approximately 40 percent of the total weight of material yarded was oversized, the result of large cull logs left in the woods during earlier harvesting operations. Of the two harvesting phases, yarding and chipping, the yarding process was generally the most limiting factor. Because of long skidding distances of up to 1300 feet and inadequate handpiling and bunching, the skidder operation was unable to supply sufficient quantities of material to fully utilize the "Chiparvestor" processing capacity.

From the landings the chips and oversized slash were transported 35 miles to the Michigan-California Lumber Company mill in Camino, California. At the mill, the material was processed with other hog fuel and utilized in a boiler system producing process steam. Conversion of the delivered hog fuel into heat energy at the mill site costs Michigan-California Lumber Company $0.217 per million Btu, assuming a moisture content (wet basis) of 50% (Lindgren, 1978). The value was adjusted to $0.193 per million Btu for use in this study as the collected slash and residue had an average moisture content (wet basis) of 29.6%.

As shown in Figure II, this project resulted in the collection of 873.3 dry tons of logging slash and residue which was converted into 11.1 billion Btu of net useful energy at a total operating cost of $3.08 per million Btu (Table I). Additional costs were incurred, such as damage to the residual stand in the form of logging scars and injury to regeneration, but these costs were minimal relative to future stand productivity and were not assessed.

Along with the production of 11.1 billion Btu of heat energy, the harvesting of forest residues resulted in the reduction of fire hazard on the site by removing an average of 21 dry tons of heavy fuels per acre.

A comparison of the costs of heat energy from fossil fuels and the wood residues produced in this project is presented in Figure III. At present subsidized prices of fossil fuel energy, wood energy as produced in this project is not cost competitive. However, this does not account for the other benefits provided by forest residue and slash collection (i.e., fire hazard reduction, seedbed and site preparation). These benefits are quantified in Figure IV. Neither does the comparison account for the reduced costs as technology modifies existing equipment for the special requirements of residue collection. Specifically, in this project, yarding costs could have been reduced by decreasing equipment operation time through increased handpiling and more efficient utilization of skidder capacities along with integrating slash collection activities into timber harvesting operations rather than complete relogging.

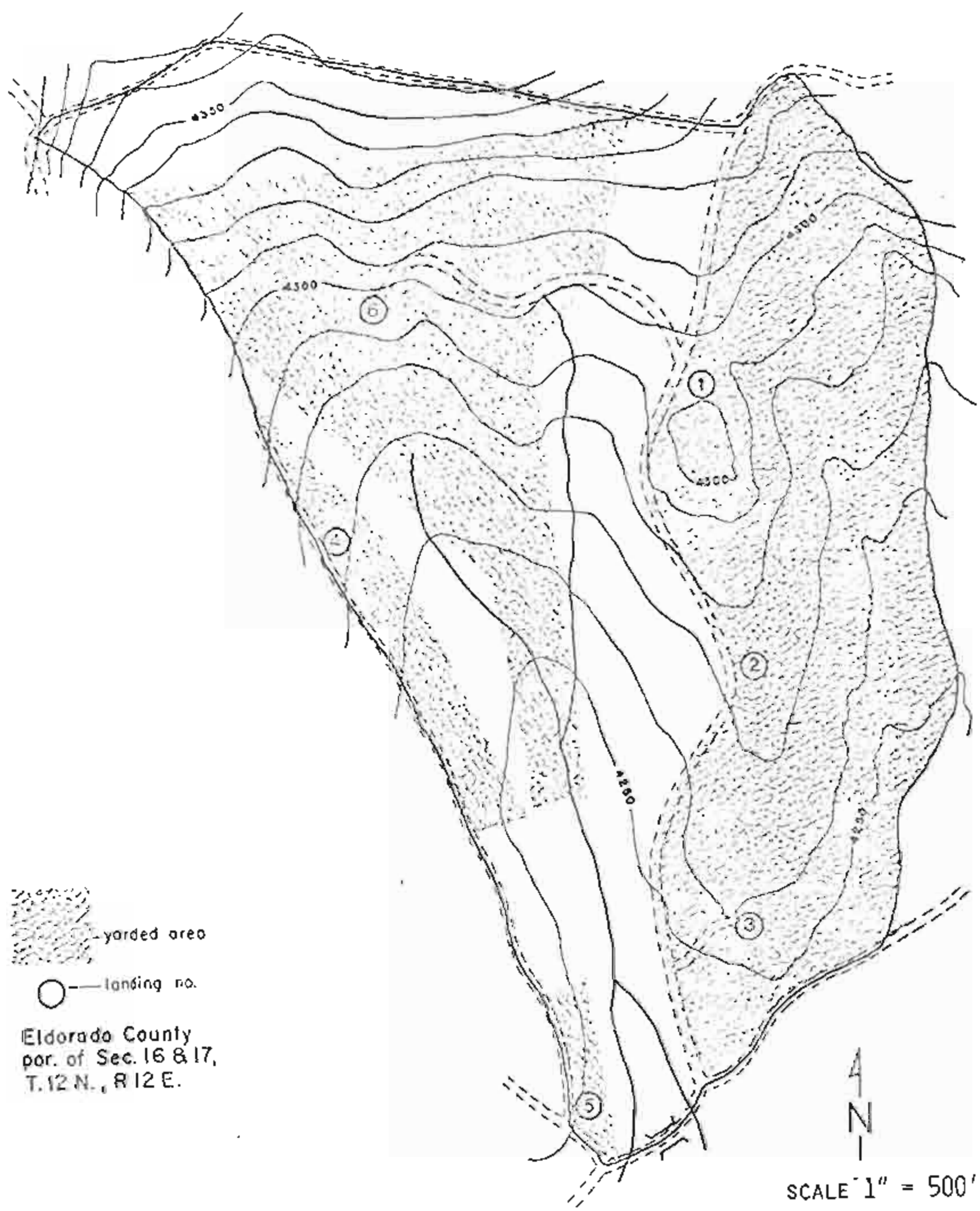
Another possible cost reduction measure would be the elimination of in-field chipping. This would involve transporting all collected slash and residues, intact, to existing hog facilities at the mill's energy plant. Because of the limited diameter-capacity of the "Chiparvestor" used on this project, 40% of the material collected was transported intact. The transport of the other 60% directly to the conversion site without first chipping it would increase transportation costs but not enough to offset the benefits of eliminating the in-field chipping expenses which accounted for over 25% of the total cost of Btu production.

One factor to consider when determining the feasibility of forest residue harvesting is the increasing acceptance of the need for reducing the level of fire hazard on managed timberlands through reduction of harvesting residues. The U.S. Forest Service currently requires logging operations on National Forest land in California to yard any logging residue greater than ten inches in diameter and ten feet in length. This material is usually decked on landings and burned or sold for salvaged lumber and firewood. Data from timber sales with levels of slash similar to those on the Blodgett project site show slash and residue treatment costs of approximately $5.00 per dry ton. This includes the yarding and burning of the large pieces and the reduction of remaining residues by slashing and burning with the inherent air quality problems open burning creates. Since the cost of yarding the slash is assessed to hazard reduction, it would be credited to the total cost of collecting, transporting and converting the material to usable energy.

While transportation of the processed residues comprised only 17.5% of total production costs, hauling distances from the harvest area to a mill or conversion site can influence the economic feasibility of utilizing forest residues for energy production. This influence is shown in Figure V which indicates that wood residues harvested on this project are currently competitive with residual fuel oils when the forest residues are transported 35 miles or less. Residues are competitive with natural gas only when the harvest site is in the immediate vicinity of the energy conversion plant. With petroleum prices increasing at rates greater than inflation, the harvest and transport of forest residues will become feasible for increasingly longer distances from energy conversion sites.

Utilizing equipment designed primarily for harvesting timber, this project harvested an average of 20.8 dry tons per acre on 42 acres at a cost of $39.06 per dry ton ($3.08 per MM Btu). With the needed development of appropriate equipment and technology specifically designed for slash collection and the utilization of residues for their highest product value (e.g., salvageable timber for lumber, quality chips for pulp production and remaining residues for energy production), the harvesting costs should decrease to a level where energy produced from logging slash and residue is more cost competitive with other sources of energy.

FIGURE 1



COMPARTMENT 500 U
Blodgett Forest Research Station

TABLE I

Production Costs (1978 Dollars)

		Project Cost	$/Dry Ton[3]	$/MMTBU[4]	Per Cent
1)	Collection[1]				
	a) Site Prep (Gill poking, etc)	$ 500	$ 0.57	$ 0.05	1.5
	b) Move in/Move out	525	0.60	0.05	1.5
	c) Yarding	13,210	15.13	1.19	38.7
	1. labor $7275				
	2. equipment 5935				
	d) Chipping	8,585	9.83	0.77	25.2
	1. labor $2650				
	2. equipment 5935				
	e) Repair and Maintenance	1,230	1.41	0.11	3.6
	f) Travel and Misc.	1,420	1.63	0.13	4.2
	g) Total Collection cost	$25,470	$ 29.17	$ 2.29	74.7
2)	Transportation[1]	6,000	6.87	0.54	17.5
3)	Road Maintenance[1]	500	0.57	0.05	1.5
4)	Cost of Conversion[2]	2,140	2.45	0.19	6.3
5)	Total Collection and Conversion Cost	$34,110	$ 39.06	$ 3.08	100.0

1. Source: Gene West, Inc., 1978
2. Cost of Converting delivered fuel to heat energy = $0.193/MMBTU
3. Total of 873.3 dry tons harvested
4. Assumes 29.6% MC (wet basis), Plant efficiency = 74.5%

FIGURE II

Total Residue and Energy Production/Consumption

Harvested Area -- 42 Acres

Total Harvest -- 1,240.49 Tons @ 29.6% MC (wet basis) or 42.5% MC (dry basis)
873.30 Dry Tons

Net Useful Energy

Assume:

Net Boiler Efficiency[1] = 74.5%
Heating Value (oven dry) = 8,500 Btu/lb. = 17 MMBtu/ton
N.U.E.[2] = 11.1 Billion Btu

Energy Consumption

Diesel Fuel[3] - 3460 gallons

Assume: 140,000 Btu/gal.

Energy Consumed = 484 MMBtu

Energy Balance Ratio

$$\frac{\text{Energy Produced}}{\text{Energy Consumed}} = \frac{11{,}100 \text{ MMBtu}}{484 \text{ MMBtu}} = 22.9$$

1. Efficiency derived from U.S. Forest Service, Fuel Value Calculator.
2. 1240.49 tons x 0.704 x 17 MMBtu/Ton x 0.745 = 11,100 MMBtu
3. Total fuel consumption for harvesting and transportation operations.

FIGURE III

Costs of Delivered Fuels

	Cents/MMBTU
Coal[1]	91.6
Residual Fuel Oil[1]	304.1
Natural Gas[1]	257.4
LPG[1]	328.8
Wood Residues from this Project	308.0

1. Source: Monthly Energy Review, January 1979 (Values for Pacific Region, August 1978) Values adjusted to assume a combustion efficiency of 85%.

FIGURE IV

INDIRECT PROJECT BENEFITS

	$/dry ton	$/MMBTU Produced
Site Preparation[1]	$ 3.85	$ 0.43
Hazard Reduction[2]	5.00	0.56
TOTAL BENEFITS	$ 8.85	$0.99

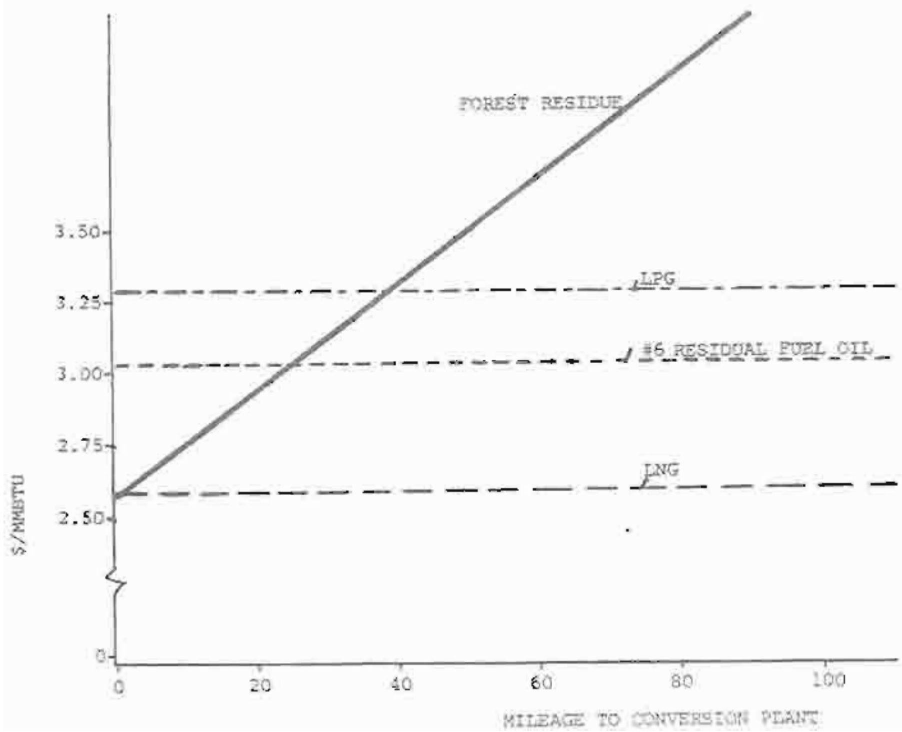
1. Assumes $80/A for site improvements including seedbed preparation and reduction of excessive cedar regeneration.

2. Assumes $5 per dry ton from figures for hazard reduction on similar sites. (Lucarelli, 1978)

FIGURE V

Delivery Cost As A Function Of

Distance From Energy Conversion Site



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